

Polycyclic Aromatic Hydrocarbons

General Information

Polycyclic aromatic hydrocarbons (PAHs) are a class of chemicals that result from the incomplete combustion of fossil fuels (e.g., coal). Exposure to these chemicals usually occurs as exposure to mixtures and not to individual chemicals. Tobacco smoking and air pollution are sources of exposure in the general population. PAHs enter the atmosphere from motor vehicle exhaust, residential and industrial furnaces, tobacco smoke, volcanoes, and forest fires. Seasonal variations in exposure to PAHs are known to occur. The soil and water near industrialized areas can contain elevated concentrations of PAHs. Another source of PAH exposure in the general population is food, including smoked, charcoal-broiled, and roasted foods and plant foods that become contaminated by atmospheric deposition. Cereal products (e.g., wheat, corn, oats, and barley) may contain PAHs because of methods used to dry them. Workers in certain occupational settings are exposed to PAHs from the burning or coking of petroleum products. Some of these occupations include working in coke production, coal gasification, and iron or steel production; working as roof tarrers, asphalt applicators, or chimney sweeps; and working with waste incineration, or

in gas refineries or aluminum smelters. Coal tar is composed of PAHs and can be used as a medical therapy for psoriasis. The U.S. Food and Drug Administration (FDA) and OSHA have developed criteria on the allowable levels of these chemicals in foods and the workplace. The U.S. EPA has set similar criteria for water and for the storage and removal of waste.

The health effect of concern associated with PAH exposure is cancer. Lung, genitourinary, and skin cancers have been reported in occupational settings, where the amount of exposure is greater than it is in the general population (Lloyd, 1971; Redmond et al., 1976, Boffetta et al., 1997). Early studies have been limited by the lack of ability to evaluate the isolated effects of individual PAH analytes and other contributing carcinogens, such as those in tobacco smoke. According to IARC, benz[a]anthracene and benzo[a]pyrene are probable human carcinogens, and benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, and indeno[1,2,3,-cd]pyrene are possible human carcinogens. The NTP lists the following chemicals as reasonably anticipated to be human carcinogens: benz[a]anthracene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, dibenz[a,h]acridine, dibenz[a,j]acridine, dibenz[a,h]anthracene, 7H-dibenzo[c,g]carbazole, dibenzo[a,e]pyrene, dibenzo[a,h]pyrene,

Table 31. Polycyclic aromatic hydrocarbons (PAHs) and their metabolites

PAH (CAS number)	Urinary hydroxylated metabolite (CAS number)
Benz[a]anthracene (56-55-3)	1-Hydroxybenz[a]anthracene (69847-26-3) 3-Hydroxybenz[a]anthracene (4834-35-9)
Benzo[c]phenanthrene (195-19-7)	1-Hydroxybenzo[c]phenanthrene 2-Hydroxybenzo[c]phenanthrene (22717-94-8) 3-Hydroxybenzo[c]phenanthrene
Chrysene (218-01-9)	3-Hydroxychrysene (63019-39-6) 6-Hydroxychrysene (37515-51-8)
Fluoranthene (206-44-0)	3-Hydroxyfluoranthrene
Fluorene (86-73-7)	2-Hydroxyfluorene (2443-58-5) 3-Hydroxyfluorene (6344-67-8)
Phenanthrene (85-01-8)	1-Hydroxyphenanthrene (2433-56-9) 2-Hydroxyphenanthrene 3-Hydroxyphenanthrene (605-87-8)
Pyrene (129-00-0)	1-Hydroxypyrene (5315-79-7)

dibenzo[a,i]pyrene, dibenzo[a,l]pyrene, indeno[1,2,3-cd]pyrene, and 5-methylchrysene (NTP 9th ROC). The U.S. EPA has classified as probable carcinogens the following: benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, indeno[1,2,3-cd]pyrene,. Pyrene was reviewed by IARC and determined it to be not classifiable as to its human carcinogenicity. The IARC, NTP, and U.S. EPA also list chemical mixtures (e.g., soot, coke-oven emissions, coal tars), which contain PAH chemicals, as known carcinogens. Information about external exposure and health effects is available from ATSDR at <http://www.atsdr.cdc.gov/toxprofiles>.

Interpreting Urine PAH Metabolite Levels in the Tables

Urinary levels of hydroxylated metabolites of PAHs were measured in a subsample of NHANES 1999-2000 participants aged 6 years old and older. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. Measurement of these 14 metabolites reflects exposure to PAHs that has occurred within the previous few days. Some of the parent PAHs can produce more than one measureable urinary metabolite. Table 31 shows the relation between PAHs and their metabolites. The hydroxylated metabolites of the PAHs are excreted in human urine both as free hydroxylated metabolites and as hydroxylated metabolites conjugated to glucuronic acid and sulfate. Measurements provided in this *Report* include both free and conjugated forms of the hydroxylated metabolites (Tables 32-59).

Measuring these metabolites at these levels is possible because of advances in analytical chemistry. Finding a measurable amount of one or more metabolites in the urine does not mean that the levels of the PAHs cause an adverse health effect. Whether levels of PAH metabolites at the levels reported here are cause for health concern is not known; more research is needed. These data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of PAHs than those found in the general population. These data will help scientists plan and conduct research on exposure to PAHs and health effects.

1-Hydroxybenz[a]anthracene and 3-Hydroxybenz[a]anthracene

Metabolites of benz[a]anthracene
(CAS No. 56-55-3)

Urinary 1-hydroxybenz[a]anthracene levels were detected in less than 3.2% of the NHANES 1999-2000 subsample. Two previous investigations in general populations have measured these two metabolites (Chuang et al., 1999, Whiton et al., 1995) and found urinary levels exceeding the concentrations measured in this NHANES 1999-2000 subsample. In another study, adults had hydroxylated benz[a]anthracene levels two to six times higher than those of children (Chuang et al., 1999). The 90th and 95th percentiles reported here

suggest that higher levels occur with decreasing age for the metabolite 3-hydroxybenz[a]anthracene. Workers manufacturing fireproof stone had 3-hydroxybenz[a]anthracene levels higher than the levels that were found in this NHANES 1999-2000 subsample (Gundel et al., 2000).

Table 32. 1-Hydroxybenz[a]anthracene

Geometric mean and selected percentiles of urine concentrations (in ng/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	2084
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	276
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	626
20 years and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1182
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1004
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1080
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	667
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	465
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	779

< LOD means less than the limit of detection, which is 4.7 ng/L.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 33. 1-Hydroxybenz[a]anthracene (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in ng/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	2084
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	276
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	626
20 years and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1182
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1004
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1080
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	667
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	465
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	779

< LOD means less than the limit of detection (see previous table).

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 34. 3-Hydroxybenz[a]anthracene

Geometric mean and selected percentiles of urine concentrations (in ng/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	7.50 (6.00-9.90)	11.6 (9.10-14.5)	2152
Age group								
6-11 years	*	< LOD	< LOD	< LOD	7.60 (<LOD-11.7)	14.4 (7.70-49.8)	32.0 (9.50-71.0)	285
12-19 years	*	< LOD	< LOD	< LOD	6.00 (<LOD-8.10)	10.7 (8.10-14.5)	14.9 (10.7-21.0)	652
20 years and older	*	< LOD	< LOD	< LOD	< LOD	5.70 (<LOD-7.20)	8.80 (6.30-12.6)	1215
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	7.80 (5.70-11.8)	13.5 (9.50-18.8)	1033
Females	*	< LOD	< LOD	< LOD	< LOD	7.20 (6.00-9.20)	10.2 (7.60-12.7)	1119
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	7.50 (6.30-9.40)	11.0 (7.90-15.7)	688
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	7.50 (5.70-11.3)	11.5 (7.50-19.0)	488
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	7.30 (5.60-10.0)	11.8 (8.80-15.6)	792

< LOD means less than the limit of detection, which is 5.4 ng/L.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 35. 3-Hydroxybenz[a]anthracene (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in ng/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	12.2 (10.0-14.6)	17.6 (15.2-21.1)	2152
Age group								
6-11 years	*	< LOD	< LOD	< LOD	9.61 (6.74-13.6)	18.1 (12.7-27.2)	23.6 (14.6-33.2)	285
12-19 years	*	< LOD	< LOD	< LOD	5.09 (4.37-6.11)	7.69 (6.44-8.84)	10.0 (8.64-11.9)	652
20 years and older	*	< LOD	< LOD	< LOD	< LOD	12.2 (10.0-14.6)	17.4 (15.2-21.1)	1215
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	9.77 (8.44-11.5)	14.7 (10.9-18.7)	1033
Females	*	< LOD	< LOD	< LOD	< LOD	14.1 (11.2-17.3)	21.1 (16.5-22.4)	1119
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	10.7 (9.27-14.1)	18.1 (12.7-21.1)	688
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	6.78 (5.85-8.62)	10.9 (7.31-14.1)	488
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	13.1 (10.3-16.5)	19.0 (16.5-22.4)	792

< LOD means less than the limit of detection (see previous table).

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

**1-Hydroxybenzo[c]phenanthrene,
2-Hydroxybenzo[c]phenanthrene, and
3-Hydroxybenzo[c]phenanthrene**

*Metabolites of benzo[c]phenanthrene
(CAS No. 195-19-7)*

Levels of 1-, 2- and 3-hydroxybenzo[c]phenanthrene are reported in Tables 36-41.

Table 36. 1-Hydroxybenzo[c]phenanthrene

Geometric mean and selected percentiles of urine concentrations (in ng/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	8.20 (6.10-11.5)	17.2 (12.9-25.0)	31.0 (21.4-42.7)	2200
Age group								
6-11 years	*	< LOD	< LOD	< LOD	9.10 (<LOD-16.4)	17.0 (10.8-32.4)	32.1 (14.9-48.4)	297
12-19 years	*	< LOD	< LOD	< LOD	9.40 (7.10-13.2)	18.0 (13.7-27.0)	31.2 (20.0-41.4)	665
20 years and older	*	< LOD	< LOD	< LOD	8.10 (<LOD-11.3)	16.9 (12.1-24.7)	30.3 (20.3-43.3)	1238
Gender								
Males	*	< LOD	< LOD	< LOD	8.40 (6.50-12.5)	18.0 (12.9-31.3)	35.4 (25.0-47.5)	1054
Females	*	< LOD	< LOD	< LOD	8.20 (<LOD-11.5)	16.5 (11.9-22.6)	24.7 (17.6-35.8)	1146
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	12.9 (8.00-17.5)	21.9 (16.2-30.3)	32.4 (23.1-47.5)	716
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	7.60 (<LOD-8.80)	12.8 (8.80-29.1)	30.3 (13.8-43.9)	497
Non-Hispanic whites	*	< LOD	< LOD	< LOD	8.40 (<LOD-12.9)	17.0 (11.9-25.8)	29.4 (18.0-47.2)	805

< LOD means less than the limit of detection, which is 5.7 ng/L.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 37. 1-Hydroxybenzo[c]phenanthrene (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in ng/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	10.1 (8.16-12.8)	22.3 (16.7-28.6)	36.1 (26.8-47.6)	2200
Age group								
6-11 years	*	< LOD	< LOD	< LOD	9.73 (7.69-15.9)	22.7 (13.0-32.8)	32.8 (21.6-63.5)	297
12-19 years	*	< LOD	< LOD	< LOD	7.69 (5.38-11.0)	16.3 (10.3-24.3)	24.3 (17.3-34.0)	665
20 years and older	*	< LOD	< LOD	< LOD	10.5 (8.51-13.3)	23.3 (16.7-30.7)	37.1 (26.8-61.4)	1238
Gender								
Males	*	< LOD	< LOD	< LOD	8.61 (6.67-10.8)	18.6 (12.7-26.8)	28.8 (23.0-37.1)	1054
Females	*	< LOD	< LOD	< LOD	11.8 (8.89-15.7)	24.3 (18.1-36.4)	40.4 (26.7-73.8)	1146
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	12.3 (9.50-17.0)	26.7 (19.0-36.3)	37.1 (28.7-48.8)	716
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	5.75 (4.65-7.41)	11.8 (8.77-18.8)	21.1 (12.5-39.6)	497
Non-Hispanic whites	*	< LOD	< LOD	< LOD	10.4 (8.17-13.5)	23.3 (15.7-30.3)	36.4 (25.8-55.0)	805

< LOD means less than the limit of detection (see previous table).

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 38. 2-Hydroxybenzo[c]phenanthrene

Geometric mean and selected percentiles of urine concentrations (in ng/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	14.3 (10.8-18.0)	21.2 (16.5-28.1)	2175
Age group								
6-11 years	*	< LOD	< LOD	< LOD	7.00 (<LOD-16.2)	19.9 (11.6-34.9)	30.2 (15.6-47.2)	285
12-19 years	*	< LOD	< LOD	< LOD	< LOD	14.0 (9.20-18.6)	20.0 (14.9-30.2)	657
20 years and older	*	< LOD	< LOD	< LOD	< LOD	13.5 (9.60-17.8)	20.1 (14.7-26.1)	1233
Gender								
Males	*	< LOD	< LOD	< LOD	7.00 (<LOD-10.3)	16.9 (12.4-23.6)	29.0 (20.7-34.9)	1046
Females	*	< LOD	< LOD	< LOD	< LOD	11.9 (8.90-16.2)	17.0 (13.6-21.3)	1129
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	12.2 (8.80-16.1)	17.0 (13.9-25.2)	686
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	10.0 (<LOD-16.0)	20.0 (14.9-30.2)	34.3 (20.3-51.6)	495
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	13.5 (9.10-19.1)	21.2 (15.2-29.4)	809

< LOD means less than the limit of detection, which is 6.8 ng/L.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 39. 2-Hydroxybenzo[c]phenanthrene (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in ng/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	2.18 (2.02-2.33)	2.98 (2.81-3.16)	4.95 (4.44-5.52)	9.80 (8.14-11.4)	20.0 (16.0-24.0)	28.2 (22.9-30.9)	2175
Age group								
6-11 years	*	< LOD	< LOD	< LOD	11.4 (9.06-16.2)	23.1 (12.0-41.7)	34.3 (20.8-47.3)	285
12-19 years	*	< LOD	< LOD	< LOD	< LOD	11.7 (8.88-14.3)	16.4 (12.0-26.1)	657
20 years and older	*	2.22 (2.01-2.38)	3.04 (2.86-3.29)	5.11 (4.53-5.75)	10.1 (8.14-12.6)	20.9 (16.0-26.3)	28.6 (23.3-34.3)	1233
Gender								
Males	*	1.97 (1.81-2.16)	2.69 (2.51-2.94)	4.32 (3.66-4.71)	8.42 (6.96-11.0)	17.3 (13.4-23.1)	25.3 (20.2-34.3)	1046
Females	*	< LOD	< LOD	< LOD	< LOD	20.9 (16.6-26.7)	30.0 (25.3-34.3)	1129
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	15.5 (11.7-20.8)	22.9 (17.3-25.0)	686
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	7.38 (6.08-10.7)	16.7 (12.1-21.5)	23.3 (19.6-28.7)	495
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	20.8 (15.4-25.3)	28.6 (23.3-34.3)	809

< LOD means less than the limit of detection (see previous table).

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 40. 3-Hydroxybenzo[c]phenanthrene

Geometric mean and selected percentiles of urine concentrations (in ng/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	2172
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	287
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	657
20 years and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1228
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1045
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1127
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	689
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	491
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	806

< LOD means less than the limit of detection, which is 4.9 ng/L.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 41. 3-Hydroxybenzo[c]phenanthrene (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in ng/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	2172
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	287
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	657
20 years and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1228
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1045
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1127
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	689
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	491
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	806

< LOD means less than the limit of detection (see previous table).

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

3-Hydroxychrysene and 6-Hydroxychrysene

Metabolites of chrysene (CAS No. 218-01-9)

The detection rates for 3-hydroxychrysene and 6-hydroxychrysene were low. In one study of families with incomes below the poverty line, Chuang et al., (1999) found that urinary 6-hydroxychrysene levels in adults and children were many times higher than those found in this NHANES 1999-2000 subsample.

Table 42. 3-Hydroxychrysene

Geometric mean and selected percentiles of urine concentrations (in ng/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	2233
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	11.0 (<LOD-44.8)	300
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	11.3 (<LOD-17.2)	674
20 years and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1259
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	10.1 (<LOD-16.5)	1067
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1166
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	< LOD	10.8 (<LOD-13.1)	722
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	515
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	806

< LOD means less than the limit of detection, which is 9.9 ng/L.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 43. 3-Hydroxychrysene (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in ng/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	2233
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	26.9 (17.9-46.2)	300
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	17.3 (14.0-20.0)	674
20 years and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1259
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	20.6 (18.4-26.2)	1067
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1166
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	< LOD	33.3 (21.9-37.1)	722
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	515
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	806

< LOD means less than the limit of detection (see previous table).

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 44. 6-Hydroxychrysene

Geometric mean and selected percentiles of urine concentrations (in ng/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	4.50 (3.90-5.00)	6.00 (5.50-6.60)	2279
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	5.00 (<LOD-6.10)	6.10 (5.20-7.60)	298
12-19 years	*	< LOD	< LOD	< LOD	< LOD	5.70 (4.30-7.70)	7.70 (4.90-11.2)	689
20 years and older	*	< LOD	< LOD	< LOD	< LOD	4.40 (<LOD-4.90)	5.80 (4.90-6.60)	1292
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	4.80 (3.60-5.70)	6.40 (5.50-7.60)	1091
Females	*	< LOD	< LOD	< LOD	< LOD	4.20 (<LOD-4.80)	5.80 (4.80-6.60)	1188
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	4.70 (3.60-5.10)	6.00 (4.90-8.10)	749
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	4.90 (<LOD-6.50)	6.80 (4.90-7.90)	515
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	4.50 (3.90-5.20)	5.90 (5.50-6.80)	826

< LOD means less than the limit of detection, which is 3.4 ng/L.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 45. 6-Hydroxychrysene (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in ng/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	8.05 (7.07-9.14)	12.6 (10.4-14.1)	2279
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	7.74 (5.11-13.1)	11.0 (8.51-24.4)	298
12-19 years	*	< LOD	< LOD	< LOD	< LOD	6.32 (4.71-9.23)	9.23 (5.83-11.5)	689
20 years and older	*	< LOD	< LOD	< LOD	< LOD	8.18 (7.07-9.60)	13.3 (11.2-15.0)	1292
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	6.67 (5.45-8.13)	9.23 (8.05-12.0)	1091
Females	*	< LOD	< LOD	< LOD	< LOD	9.88 (8.00-11.4)	14.1 (12.6-17.1)	1188
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	8.05 (5.45-11.4)	13.3 (8.05-23.8)	749
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	4.62 (3.91-5.71)	7.50 (5.71-7.93)	515
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	8.57 (7.75-10.4)	13.1 (11.4-15.5)	826

< LOD means less than the limit of detection (see previous table).

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

3-Hydroxyfluoranthene

Metabolite of fluoranthene (CAS No. 206-44-0)

For this metabolite, geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, urinary creatinine, and log serum cotinine. No differences were observed. Chuang et al. (1999) measured levels of 3-hydroxyfluoranthene in a selected population of families with incomes below the poverty line and found that the mean urinary levels in adults and children were approximately 10-fold higher than levels seen in the NHANES 1999-2000 subsample.

Table 46. 3-Hydroxyfluoranthene

Geometric mean and selected percentiles of urine concentrations (in ng/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	13.4 (10.3-17.3)	< LOD	< LOD	17.5 (11.0-23.1)	32.3 (28.8-38.4)	58.6 (49.2-74.0)	98.8 (77.2-147)	2236
Age group								
6-11 years	12.6 (9.33-16.9)	< LOD	< LOD	15.8 (5.70-22.5)	37.6 (25.1-45.1)	65.7 (45.1-146)	138 (57.1-216)	308
12-19 years	15.0 (10.7-21.1)	< LOD	< LOD	20.3 (9.30-28.4)	38.7 (29.9-47.6)	60.6 (47.6-98.5)	98.9 (62.2-260)	675
20 years and older	13.2 (10.2-17.3)	< LOD	< LOD	17.3 (11.4-22.6)	31.1 (27.6-37.2)	58.2 (45.5-78.9)	90.7 (71.7-150)	1253
Gender								
Males	13.5 (10.2-17.8)	< LOD	< LOD	17.4 (10.6-23.4)	32.6 (28.8-40.2)	58.2 (46.2-78.7)	98.8 (70.3-162)	1074
Females	13.3 (10.2-17.4)	< LOD	< LOD	17.5 (10.2-22.7)	31.8 (27.3-38.2)	58.7 (47.0-79.6)	88.4 (71.7-138)	1162
Race/ethnicity								
Mexican Americans	14.0 (10.1-19.4)	< LOD	< LOD	17.1 (10.1-23.9)	30.4 (25.6-40.8)	52.1 (44.4-67.6)	96.6 (65.6-312)	715
Non-Hispanic blacks	14.0 (9.51-20.6)	< LOD	< LOD	17.7 (6.40-26.8)	38.2 (27.2-55.8)	89.3 (57.6-163)	185 (96.9-283)	527
Non-Hispanic whites	13.2 (9.77-17.8)	< LOD	< LOD	17.3 (9.90-24.2)	32.0 (27.8-39.4)	54.3 (43.8-74.0)	87.3 (63.0-146)	802

< LOD means less than the limit of detection, which is 3.5 ng/L.

Table 47. 3-Hydroxyfluoranthene (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in ng/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	12.4 (9.38-16.3)	< LOD	< LOD	14.7 (9.96-20.4)	36.3 (28.6-43.8)	67.9 (56.0-83.2)	102 (83.2-129)	2236
Age group								
6-11 years	12.8 (9.31-17.7)	< LOD	< LOD	13.7 (5.95-25.3)	44.3 (25.3-56.3)	77.0 (53.2-115)	131 (67.3-254)	308
12-19 years	10.1 (6.83-14.9)	< LOD	< LOD	13.4 (7.08-20.3)	29.1 (21.5-42.7)	54.9 (37.4-86.0)	92.1 (60.6-134)	675
20 years and older	12.7 (9.68-16.7)	< LOD	< LOD	14.8 (10.2-20.8)	36.5 (28.9-43.0)	68.9 (56.0-83.2)	102 (80.5-129)	1253
Gender								
Males	10.7 (8.01-14.2)	< LOD	< LOD	12.1 (8.18-17.5)	32.9 (23.9-40.0)	62.5 (50.0-74.7)	91.3 (74.7-122)	1074
Females	14.2 (10.7-18.9)	< LOD	< LOD	17.5 (11.7-24.1)	39.6 (31.4-46.8)	75.5 (61.2-90.5)	107 (85.7-175)	1162
Race/ethnicity								
Mexican Americans	12.7 (8.95-18.1)	< LOD	< LOD	13.8 (9.10-20.5)	30.7 (23.0-43.4)	64.1 (51.1-94.8)	107 (83.4-153)	715
Non-Hispanic blacks	9.21 (6.07-14.0)	< LOD	< LOD	10.4 (4.31-17.8)	30.2 (20.2-40.0)	72.6 (51.0-107)	133 (84.3-216)	527
Non-Hispanic whites	13.1 (9.58-17.9)	< LOD	< LOD	16.0 (9.76-23.6)	36.9 (28.6-45.7)	68.8 (54.2-83.2)	90.6 (74.7-129)	802

< LOD means less than the limit of detection (see previous table).

2-Hydroxyfluorene and 3-Hydroxyfluorene

Metabolites of fluorene (CAS No. 86-73-7)

Geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, urinary creatinine, and log serum cotinine. No differences were observed.

Table 48. 2-Hydroxyfluorene

Geometric mean and selected percentiles of urine concentrations (in ng/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	441 (330-590)	55.9 (36.8-81.6)	141 (107-192)	422 (279-706)	1350 (1030-2030)	3710 (2770-4650)	6450 (4720-8380)	2315
Age group								
6-11 years	294 (216-400)	62.1 (19.4-92.1)	124 (90.2-167)	262 (171-447)	780 (507-1240)	1800 (984-2220)	2010 (1410-5400)	306
12-19 years	469 (326-673)	79.7 (49.8-107)	187 (116-257)	421 (275-861)	1410 (932-2200)	2810 (2160-4390)	4980 (3100-6920)	694
20 years and older	461 (343-620)	50.8 (34.1-79.9)	136 (106-193)	456 (296-770)	1510 (1120-2300)	4280 (3010-5380)	7270 (4910-9520)	1315
Gender								
Males	474 (341-659)	75.4 (39.8-102)	156 (116-208)	468 (261-802)	1450 (957-2290)	3780 (2730-5050)	6920 (4600-10900)	1106
Females	412 (312-544)	45.7 (32.7-65.2)	131 (97.0-166)	385 (277-666)	1330 (988-1960)	3600 (2730-4650)	5790 (4410-9240)	1209
Race/ethnicity								
Mexican Americans	296 (225-390)	58.2 (42.1-70.4)	108 (81.8-143)	268 (174-423)	807 (481-1290)	1870 (1230-2530)	2930 (1910-4760)	750
Non-Hispanic blacks	646 (416-1000)	70.7 (45.8-125)	188 (119-332)	680 (341-1230)	2140 (1250-3320)	5790 (3310-10600)	10800 (5030-18500)	534
Non-Hispanic whites	419 (294-596)	45.7 (26.8-83.9)	131 (96.5-198)	402 (244-755)	1320 (903-2160)	3990 (2730-4660)	6450 (4640-8710)	841

Table 49. 2-Hydroxyfluorene (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in ng/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	408 (302-551)	68.9 (47.4-93.6)	146 (109-202)	382 (274-640)	1160 (841-1500)	2880 (2170-4040)	5270 (3820-6390)	2315
Age group								
6-11 years	307 (216-437)	79.0 (30.9-99.7)	121 (91.0-177)	336 (168-648)	787 (570-1200)	1380 (1010-2180)	1740 (1350-2950)	306
12-19 years	314 (219-450)	63.5 (37.8-82.7)	119 (83.7-186)	369 (206-543)	785 (600-1240)	1880 (1260-2570)	2570 (1920-4090)	694
20 years and older	443 (328-597)	69.4 (47.4-99.8)	155 (114-211)	400 (290-668)	1260 (880-1780)	3480 (2430-4880)	6040 (4290-7560)	1315
Gender								
Males	376 (267-528)	64.0 (33.6-92.1)	134 (99.8-177)	378 (250-630)	1070 (756-1460)	2440 (1830-4250)	4870 (2870-6750)	1106
Females	441 (332-584)	76.7 (54.3-103)	162 (119-213)	393 (282-686)	1260 (871-1630)	3300 (2440-4400)	5490 (3800-7420)	1209
Race/ethnicity								
Mexican Americans	275 (202-375)	68.7 (54.2-87.7)	120 (85.3-167)	252 (166-417)	597 (418-867)	1350 (884-1720)	2090 (1410-3110)	750
Non-Hispanic blacks	425 (266-677)	55.1 (20.5-97.0)	138 (79.5-252)	541 (222-882)	1190 (826-1960)	3090 (1760-6040)	6040 (3090-8500)	534
Non-Hispanic whites	414 (289-594)	68.8 (27.4-99.8)	142 (104-215)	391 (259-702)	1260 (828-1660)	3130 (2100-4800)	5620 (3820-6860)	841

Table 50. 3-Hydroxyfluorene

Geometric mean and selected percentiles of urine concentrations (in ng/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	171 (129-225)	16.7 (<LOD-25.1)	45.2 (35.5-64.0)	151 (104-235)	572 (401-813)	1840 (1460-2380)	3390 (2530-4540)	2312
Age group								
6-11 years	105 (76.5-144)	16.4 (<LOD-37.3)	39.4 (28.9-61.3)	92.8 (65.9-141)	247 (146-371)	615 (328-863)	851 (546-2390)	306
12-19 years	192 (137-270)	27.8 (<LOD-40.1)	70.0 (40.1-107)	198 (133-284)	621 (371-879)	1330 (948-1930)	2110 (1480-2400)	692
20 years and older	178 (133-240)	16.0 (<LOD-23.5)	43.5 (31.8-61.9)	156 (108-257)	639 (426-985)	2080 (1600-2700)	4060 (2700-4680)	1314
Gender								
Males	189 (137-259)	22.5 (<LOD-31.7)	50.0 (37.2-73.2)	167 (97.1-268)	689 (404-1010)	2060 (1480-2700)	3520 (2690-4680)	1105
Females	155 (118-204)	< LOD	41.8 (31.6-53.6)	141 (105-216)	478 (350-688)	1710 (987-2290)	3010 (1920-4430)	1207
Race/ethnicity								
Mexican Americans	105 (78.3-142)	15.8 (<LOD-18.9)	34.8 (24.2-47.0)	96.7 (57.7-154)	313 (196-472)	862 (472-1490)	1490 (941-1650)	748
Non-Hispanic blacks	266 (173-409)	26.4 (<LOD-46.1)	79.4 (43.6-118)	257 (136-445)	954 (525-1390)	2800 (1630-4920)	5290 (2550-8130)	534
Non-Hispanic whites	162 (115-226)	< LOD	42.2 (28.4-63.1)	137 (86.0-238)	557 (354-863)	1910 (1250-2670)	3590 (2490-4680)	841

< LOD means less than the limit of detection, which is 15.1 ng/L.

Table 51. 3-Hydroxyfluorene (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in ng/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	157 (118-210)	22.1 (15.1-30.5)	49.4 (35.6-67.4)	135 (93.5-202)	482 (321-714)	1510 (1020-2300)	2710 (1840-4010)	2312
Age group								
6-11 years	110 (78.2-154)	21.7 (8.17-37.9)	46.8 (29.0-66.9)	111 (66.9-187)	268 (175-401)	504 (324-832)	832 (472-1540)	306
12-19 years	129 (91.8-181)	22.8 (8.97-29.7)	49.0 (29.6-81.3)	140 (85.5-216)	374 (240-484)	799 (519-1120)	1130 (955-1390)	692
20 years and older	171 (126-231)	22.2 (16.0-31.5)	50.9 (37.6-67.4)	138 (97.9-213)	613 (362-913)	1820 (1270-2640)	3020 (2370-4100)	1314
Gender								
Males	150 (108-208)	20.1 (10.7-30.9)	43.5 (31.2-68.2)	128 (85.3-204)	496 (317-714)	1390 (913-2060)	2710 (1650-4100)	1105
Females	165 (124-219)	< LOD	54.1 (39.3-67.8)	138 (97.9-206)	477 (312-779)	1650 (1080-2330)	2860 (2000-3790)	1207
Race/ethnicity								
Mexican Americans	97.7 (70.2-136)	19.5 (15.3-25.2)	38.3 (24.9-56.0)	88.5 (60.0-132)	220 (149-331)	665 (345-977)	987 (721-1470)	748
Non-Hispanic blacks	175 (111-276)	23.1 (11.3-33.5)	54.0 (29.1-103)	176 (91.9-318)	550 (329-976)	1590 (978-2540)	2710 (1810-3390)	534
Non-Hispanic whites	160 (113-226)	< LOD	46.8 (33.8-69.6)	138 (85.9-215)	505 (317-807)	1650 (1050-2460)	2920 (2130-4100)	841

< LOD means less than the limit of detection (see previous table).

1-Hydroxyphenanthrene, 2-Hydroxyphenanthrene, and 3-Hydroxyphenanthrene

Metabolites of phenanthrene (CAS No. 85-01-8)

Geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, urinary creatinine, and log serum cotinine. Children aged 6-11 years had a slightly higher urinary 3-hydroxyphenanthrene level than people in the other two age groups. Among residents of a housing unit in Germany, children younger than 6 years of age had slightly higher mean urinary (1-, 2-, 3- and 4-hydroxyphenanthrene) levels than people in the older age groups (Heudorf et al., 2001). Levels of urinary 1-

hydroxyphenanthrene in the NHANES 1999-2000 subsample were higher in females than in males. No other differences were observed.

Table 52. 1-Hydroxyphenanthrene

Geometric mean and selected percentiles of urine concentrations (in ng/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	154 (128-186)	28.3 (21.3-37.9)	65.0 (52.8-83.2)	160 (123-211)	367 (301-462)	698 (610-833)	1070 (886-1360)	2246
Age group								
6-11 years	121 (95.7-153)	21.3 (<LOD-39.8)	57.6 (42.4-72.3)	102 (83.2-162)	257 (207-370)	513 (337-668)	666 (513-1540)	294
12-19 years	167 (133-210)	39.0 (26.6-47.3)	76.4 (56.2-99.8)	175 (137-229)	353 (260-473)	688 (477-1090)	1080 (721-1630)	680
20 years and older	157 (129-191)	27.7 (21.3-37.3)	64.7 (52.0-86.3)	163 (124-216)	400 (308-488)	739 (642-869)	1100 (903-1360)	1272
Gender								
Males	153 (124-188)	32.2 (23.5-43.0)	66.4 (52.9-89.9)	147 (106-207)	351 (277-473)	680 (585-845)	1020 (794-1330)	1072
Females	156 (128-188)	25.8 (17.6-34.1)	63.7 (51.8-80.7)	172 (131-222)	372 (301-462)	753 (609-946)	1100 (946-1450)	1174
Race/ethnicity								
Mexican Americans	112 (97.0-130)	30.2 (22.3-34.1)	55.3 (46.9-68.4)	113 (93.3-142)	230 (191-297)	447 (352-506)	618 (484-728)	727
Non-Hispanic blacks	162 (119-221)	24.7 (15.7-45.2)	67.3 (49.9-84.4)	170 (102-252)	441 (295-609)	821 (649-1130)	1210 (833-2250)	516
Non-Hispanic whites	154 (123-194)	27.0 (17.2-39.2)	64.7 (48.4-88.1)	157 (114-222)	378 (281-495)	704 (604-886)	1060 (886-1390)	814

< LOD means less than the limit of detection, which is 15.0 ng/L.

Table 53. 1-Hydroxyphenanthrene (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in ng/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	142 (116-173)	31.3 (22.4-44.2)	68.8 (54.8-88.2)	143 (114-184)	299 (248-363)	571 (478-652)	907 (693-1200)	2246
Age group								
6-11 years	127 (97.8-165)	23.7 (14.6-44.8)	67.5 (44.2-86.7)	135 (95.3-193)	265 (185-372)	457 (344-619)	622 (462-1200)	294
12-19 years	112 (88.2-141)	28.7 (13.3-43.5)	62.4 (43.8-86.9)	121 (102-144)	207 (165-278)	406 (293-596)	661 (431-972)	680
20 years and older	150 (123-183)	33.5 (23.0-47.5)	70.8 (56.2-92.8)	150 (117-194)	321 (265-385)	603 (494-701)	973 (774-1330)	1272
Gender								
Males	120 (97.2-149)	28.6 (17.6-39.3)	59.9 (44.1-76.2)	124 (99.9-157)	260 (214-307)	479 (383-618)	692 (606-887)	1072
Females	166 (135-203)	37.2 (23.0-56.2)	82.1 (63.7-99.3)	166 (127-205)	351 (272-421)	631 (509-847)	1120 (803-1530)	1174
Race/ethnicity								
Mexican Americans	104 (86.8-125)	33.3 (24.0-43.6)	59.8 (47.5-71.6)	104 (83.7-133)	192 (163-227)	327 (257-425)	474 (383-672)	727
Non-Hispanic blacks	107 (76.6-149)	17.0 (9.56-31.9)	43.3 (27.2-73.5)	109 (76.5-166)	269 (194-351)	548 (390-802)	887 (595-1240)	516
Non-Hispanic whites	151 (119-192)	33.6 (20.5-52.9)	74.7 (53.3-99.9)	153 (114-201)	323 (259-390)	580 (484-729)	1010 (711-1370)	814

Table 54. 2-Hydroxyphenanthrene

Geometric mean and selected percentiles of urine concentrations (in ng/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	98.4 (82.9-117)	13.5 (<LOD-17.8)	40.3 (29.3-49.9)	107 (86.5-127)	240 (202-316)	545 (452-689)	828 (738-928)	2179
Age group								
6-11 years	79.8 (61.1-104)	13.7 (<LOD-28.7)	37.2 (22.2-44.3)	74.1 (50.9-113)	189 (113-283)	401 (229-626)	698 (401-1140)	291
12-19 years	109 (84.5-141)	17.8 (11.3-33.5)	54.0 (35.8-73.8)	112 (87.3-149)	233 (174-313)	529 (368-721)	767 (529-1340)	650
20 years and older	99.5 (83.2-119)	13.2 (<LOD-17.2)	39.1 (25.1-50.9)	108 (86.5-134)	253 (212-332)	571 (472-702)	864 (759-928)	1238
Gender								
Males	107 (88.4-131)	14.9 (<LOD-23.9)	44.2 (31.4-53.5)	109 (89.1-136)	263 (214-355)	592 (450-767)	928 (698-1370)	1048
Females	90.6 (76.2-108)	12.1 (<LOD-16.5)	36.5 (24.2-46.6)	105 (82.8-127)	226 (183-307)	514 (413-612)	797 (612-876)	1131
Race/ethnicity								
Mexican Americans	87.5 (71.8-107)	11.2 (<LOD-18.0)	39.7 (30.1-47.6)	92.3 (67.9-125)	217 (174-276)	432 (329-482)	583 (439-913)	698
Non-Hispanic blacks	131 (99.1-172)	17.7 (<LOD-35.7)	47.5 (40.3-63.6)	141 (84.2-218)	370 (253-486)	698 (506-998)	1080 (809-2280)	509
Non-Hispanic whites	91.7 (73.7-114)	12.3 (<LOD-17.0)	33.9 (23.0-47.4)	103 (76.6-127)	231 (188-319)	514 (408-714)	810 (680-889)	791

< LOD means less than the limit of detection, which is 11.2 ng/L.

Table 55. 2-Hydroxyphenanthrene (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in ng/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	90.4 (76.3-107)	21.9 (15.5-30.1)	45.0 (38.0-53.3)	89.8 (74.3-108)	188 (154-237)	368 (319-429)	521 (442-695)	2179
Age group								
6-11 years	84.0 (65.8-107)	20.3 (6.22-32.8)	40.5 (27.2-60.2)	74.4 (62.3-88.1)	173 (104-282)	350 (260-413)	413 (342-790)	291
12-19 years	74.0 (59.7-91.6)	22.3 (11.9-30.2)	40.5 (34.5-51.0)	75.0 (59.4-88.0)	133 (107-186)	295 (209-400)	441 (299-781)	650
20 years and older	94.4 (79.3-112)	21.6 (15.5-30.4)	45.8 (38.8-55.2)	94.9 (75.9-117)	197 (169-243)	392 (331-443)	573 (501-762)	1238
Gender								
Males	85.4 (70.9-103)	19.0 (13.6-30.4)	44.3 (37.2-54.8)	80.6 (67.8-101)	175 (142-206)	375 (303-426)	544 (423-786)	1048
Females	95.5 (80.2-114)	23.9 (16.1-31.7)	45.3 (38.8-52.4)	97.1 (80.9-119)	207 (163-262)	367 (310-448)	536 (410-725)	1131
Race/ethnicity								
Mexican Americans	80.2 (66.2-97.2)	24.6 (15.5-30.4)	41.9 (34.3-52.6)	77.3 (62.8-99.4)	155 (124-189)	310 (236-368)	382 (304-618)	698
Non-Hispanic blacks	86.9 (64.6-117)	14.9 (10.1-24.8)	38.9 (23.4-54.8)	93.3 (59.3-134)	207 (152-279)	408 (293-602)	664 (470-961)	509
Non-Hispanic whites	89.4 (72.2-111)	21.6 (13.6-34.3)	45.7 (37.7-56.7)	87.8 (71.5-108)	188 (147-254)	366 (302-438)	536 (436-778)	791

< LOD means less than the limit of detection (see previous table).

Table 56. 3-Hydroxyphenanthrene

Geometric mean and selected percentiles of urine concentrations (in ng/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	127 (112-144)	27.8 (23.5-34.2)	67.3 (53.2-81.0)	138 (121-155)	256 (227-295)	464 (400-547)	657 (594-721)	2299
Age group								
6-11 years	136 (113-163)	36.4 (23.3-55.2)	81.2 (63.9-98.0)	140 (113-186)	247 (195-301)	383 (291-632)	622 (316-794)	302
12-19 years	147 (123-176)	41.6 (27.8-65.4)	84.8 (73.4-109)	163 (130-207)	281 (229-325)	417 (363-547)	611 (462-720)	700
20 years and older	122 (107-140)	25.8 (20.3-32.7)	62.2 (48.8-77.7)	133 (111-152)	254 (224-295)	477 (409-559)	671 (579-760)	1297
Gender								
Males	141 (122-164)	33.2 (25.9-44.6)	76.7 (59.8-93.4)	149 (128-173)	287 (236-341)	495 (428-608)	658 (576-788)	1100
Females	114 (100-130)	24.1 (15.7-30.2)	58.4 (48.6-75.0)	130 (105-147)	242 (210-274)	399 (341-515)	624 (506-760)	1199
Race/ethnicity								
Mexican Americans	113 (100-127)	29.9 (24.3-37.9)	61.5 (54.7-73.7)	120 (96.6-145)	231 (186-255)	353 (296-438)	495 (398-580)	763
Non-Hispanic blacks	174 (138-219)	32.5 (23.2-52.6)	84.4 (56.5-113)	182 (137-228)	390 (319-447)	671 (527-913)	1110 (690-2750)	522
Non-Hispanic whites	120 (102-140)	25.7 (15.7-34.2)	63.4 (46.2-81.0)	134 (111-157)	248 (218-291)	448 (363-547)	632 (513-721)	820

Table 57. 3-Hydroxyphenanthrene (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in ng/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	116 (102-133)	38.6 (26.5-48.9)	69.8 (58.5-80.4)	121 (106-136)	198 (176-227)	365 (316-398)	480 (418-566)	2299
Age group								
6-11 years	143 (116-175)	40.6 (23.3-80.5)	96.0 (74.3-120)	155 (128-179)	226 (187-327)	416 (264-440)	440 (389-525)	302
12-19 years	99.3 (85.0-116)	38.3 (17.4-49.6)	67.2 (54.7-80.9)	112 (93.0-124)	173 (144-191)	261 (215-311)	317 (278-402)	700
20 years and older	116 (101-134)	38.5 (26.7-48.2)	68.0 (57.9-77.3)	118 (104-134)	201 (175-232)	374 (334-410)	502 (436-675)	1297
Gender								
Males	111 (95.0-131)	35.4 (19.1-48.2)	66.9 (53.6-79.3)	122 (105-134)	189 (167-216)	355 (268-418)	470 (389-627)	1100
Females	121 (106-138)	40.8 (28.7-50.8)	71.7 (63.2-83.5)	120 (105-142)	214 (175-243)	369 (331-400)	487 (402-608)	1199
Race/ethnicity								
Mexican Americans	105 (93.4-118)	44.6 (35.1-51.5)	66.5 (59.1-78.5)	107 (93.1-124)	161 (146-177)	244 (205-303)	368 (302-415)	763
Non-Hispanic blacks	115 (89.5-147)	28.3 (11.5-45.5)	59.4 (38.5-93.0)	120 (98.7-158)	213 (174-270)	410 (330-535)	652 (461-959)	522
Non-Hispanic whites	117 (99.6-139)	39.2 (23.0-52.1)	70.4 (58.0-84.6)	124 (105-143)	203 (175-240)	373 (316-418)	480 (400-574)	820

1-Hydroxypyrene

Metabolite of pyrene (CAS No. 129-00-0)

Pyrene is commonly found in PAH mixtures, and its urinary metabolite is used as a surrogate marker for exposure to PAH chemicals in general. The 1-hydroxypyrene metabolite was detected in 99% of the NHANES 1999-2000 subsample. The geometric mean level for the overall population is similar to that of other general populations residing in an urban setting (Goen et al., 1995; Chuang et al., 1999). People living in one urban setting had severalfold higher urinary 1-hydroxypyrene levels than those who lived in a rural setting (Goen et al., 1995). The sources of PAH exposure in the urban setting include industrial and automobile

exhaust (Jongeneelen et al., 1994; Kanoh et al., 1993). An additional source of PAH exposure is the use of coal for domestic heating. Women residing in an urban setting and using coal to heat their homes had higher urinary 1-hydroxypyrene levels than the women in this NHANES 1999-2000 subsample (Gundel et al., 1996). Tobacco smoking can be a more significant source of PAHs than urban exposures or road construction exposure (Goen et al., 1995; Szaniszlo et al., 2001). People who work in certain occupations (e.g., carbon electrode production) can have urinary 1-hydroxypyrene levels 100 times higher than the geometric mean level shown in this *Report* (Goen et al., 1995). An additional source of PAH exposure for children is the ingestion of PAH-contaminated soil.

Table 58. 1-Hydroxypyrene

Geometric mean and selected percentiles of urine concentrations (in ng/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	79.8 (69.0-92.2)	14.9 (11.7-18.6)	34.7 (27.4-41.6)	78.0 (67.8-92.8)	187 (161-229)	434 (371-506)	730 (551-940)	2312
Age group								
6-11 years	90.8 (72.2-114)	20.8 (14.8-39.8)	57.0 (39.8-70.7)	94.1 (77.9-124)	170 (124-229)	300 (206-405)	419 (293-757)	310
12-19 years	105 (85.0-129)	24.1 (18.9-33.5)	48.0 (38.7-61.0)	108 (78.1-141)	226 (171-290)	473 (317-618)	642 (425-1200)	693
20 years and older	74.8 (64.0-87.4)	13.6 (9.90-16.3)	30.7 (24.3-36.7)	70.1 (62.2-85.0)	187 (156-233)	446 (366-570)	795 (570-977)	1309
Gender								
Males	90.1 (76.0-107)	18.0 (12.7-23.5)	37.1 (28.4-48.5)	85.2 (72.9-101)	227 (178-284)	496 (404-596)	747 (570-1050)	1106
Females	71.2 (61.6-82.3)	13.5 (9.40-15.8)	32.1 (26.2-37.3)	70.9 (63.3-86.1)	163 (149-197)	361 (278-451)	669 (387-940)	1206
Race/ethnicity								
Mexican Americans	74.2 (64.5-85.4)	16.3 (14.3-19.7)	34.0 (29.9-39.6)	68.1 (58.9-82.8)	161 (120-225)	344 (270-468)	545 (413-650)	766
Non-Hispanic blacks	108 (87.0-135)	20.8 (17.6-24.0)	46.6 (34.5-59.0)	99.7 (74.8-148)	245 (199-358)	586 (420-778)	839 (569-1380)	528
Non-Hispanic whites	73.7 (61.1-88.9)	13.8 (8.50-17.6)	31.9 (23.9-40.1)	72.9 (62.8-87.7)	178 (153-229)	399 (324-506)	747 (451-977)	831

Geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, urinary creatinine, and log serum cotinine. Children aged 6-11 years had about a two times higher urinary 1-hydroxypyrene adjusted geometric mean than did people in the two other age groups. This age-related difference also has been found by other investigators (Heudorf et al., 2001; Chuang et al., 1999). The urinary 1-hydroxypyrene levels for children documented in this *Report* are similar to levels measured in other studies (van Wijnen et al., 1996; Chuang et al., 1999; Heudorf et al., 2001; Kanoh et al., 1993). No differences were observed for race/ethnicity or gender. In previous investigations (Roggi et al., 1997; Kanoh et al., 1993; van Wijnen et al., 1996), gender did

not influence urinary 1-hydroxypyrene levels. It is unknown whether differences in age groups represent differences in exposure, body-size relationships, or metabolism. Further research on the contribution of tobacco smoke to levels of 1-hydroxypyrene levels is needed.

Table 59. 1-Hydroxypyrene (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in ng/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	74.2 (64.1-85.9)	18.2 (14.6-22.4)	36.5 (30.0-41.9)	73.3 (63.4-83.8)	158 (139-178)	362 (282-416)	500 (438-607)	2312
Age group								
6-11 years	94.1 (76.9-115)	31.6 (13.1-46.5)	56.5 (45.7-65.6)	91.2 (82.1-107)	168 (124-237)	333 (231-486)	474 (332-849)	310
12-19 years	71.5 (60.4-84.5)	21.0 (14.9-29.1)	36.5 (30.9-46.8)	70.7 (56.0-89.8)	137 (119-170)	240 (184-380)	413 (236-663)	693
20 years and older	72.3 (61.6-84.8)	17.2 (12.5-21.5)	33.5 (27.5-40.0)	68.8 (59.5-81.5)	159 (135-182)	377 (288-441)	541 (447-633)	1309
Gender								
Males	72.1 (60.0-86.7)	16.1 (9.59-22.2)	32.6 (25.6-42.9)	69.9 (61.0-84.3)	167 (134-185)	349 (273-416)	525 (412-709)	1106
Females	76.1 (66.2-87.6)	19.9 (17.0-25.9)	37.8 (33.1-42.1)	77.2 (61.7-86.6)	148 (129-178)	370 (256-450)	500 (434-607)	1206
Race/ethnicity								
Mexican Americans	68.2 (59.3-78.4)	21.5 (19.7-25.6)	36.1 (31.2-39.5)	59.6 (52.4-71.5)	124 (97.9-152)	252 (203-333)	462 (325-557)	766
Non-Hispanic blacks	70.5 (56.6-87.9)	16.1 (12.6-19.3)	30.3 (25.0-41.2)	68.6 (54.4-92.7)	156 (113-184)	346 (232-441)	474 (338-847)	528
Non-Hispanic whites	73.2 (60.8-88.1)	17.4 (10.4-23.5)	34.4 (28.2-42.1)	72.3 (59.9-85.7)	163 (130-188)	377 (269-450)	547 (447-633)	831